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For: LITHOGRAPHIC PROJECTION APPARATUS AND PARTICLE BARRIER FOR USE THEREIN

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Attached please find the certified copy of the foreign application from which priority is claimed for this case:

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The attached documents are exact copies of the European patent application described on the following page, as originally filed.

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Patentanmeldung Nr. Patent application No. Demande de brevet n°

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For the President of the European Patent Office

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Si aucun titre n'est indiqué se referer à la description.)

Lithographic projection apparatus and particle barrier for use in said apparatus

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Lithographic projection apparatus and particle barrier for use in said apparatus

The invention relates to a lithographic projection apparatus comprising:

- a radiation system to form a projection beam of radiation, from radiation emitted by a radiation source,
- a support structure constructed to hold patterning means, to be irradiated by the projection beam to pattern said projection beam,
- a substrate table constructed to hold a substrate, and
- a projection system constructed and arranged to image an irradiated portion of the patterning means onto a target portion of the substrate,

and a channel means near the source for preventing material emanating from the source from propagating along an optical axis, the channel means comprising a center and a number of elongated wall members having a width direction transverse to the optical axis and a length direction extending generally in the direction of the optical axis.

The term "patterning means" as here employed should be broadly interpreted as referring to means that can be used to endow an incoming radiation beam with a patterned cross-section, corresponding to a pattern that is to be created in a target portion of the substrate; the term "light valve" can also be used in this context. Generally, the said pattern will correspond to a particular functional layer in a device being created in the target portion, such as an integrated circuit or other device (see below). Examples of such patterning means include:

- A mask. The concept of a mask is well known in lithography, and it includes mask types such as binary, alternating phase-shift, and attenuated phase-shift, as well as various hybrid mask types. Placement of such a mask in the radiation beam causes selective transmission (in the case of a transmissive mask) or reflection (in the case of a reflective mask) of the radiation impinging on the mask, according to the pattern on the mask. In the case of a mask, the support structure will generally be a mask table, which ensures that the mask can be held at a desired position in the incoming radiation beam, and that it can be moved relative to the beam if so desired;
- A programmable mirror array. One example of such a device is a matrix-addressable surface having a viscoelastic control layer and a reflective surface. The basic principle behind such an apparatus is that (for example) addressed areas of the reflective surface reflect incident light as diffracted light, whereas unaddressed areas

reflect incident light as undiffracted light. Using an appropriate filter, the said undiffracted light can be filtered out of the reflected beam, leaving only the diffracted light behind; in this manner, the beam becomes patterned according to the addressing pattern of the matrix-adressable surface. An alternative embodiment of a programmable mirror array employs a matrix arrangement of tiny mirrors, each of which can be individually tilted about an axis by applying a suitable localized electric field, or by employing piezoelectric actuation means. Once again, the mirrors are matrix-addressable, such that addressed mirrors will reflect an incoming radiation beam in a different direction to unaddressed mirrors; in this manner, the reflected beam is patterned according to the addressing pattern of the matrix-adressable mirrors. The required matrix addressing can be performed using suitable electronic means. In both of the situations described hereabove, the patterning means can comprise one or more programmable mirror arrays. More information on mirror arrays as here referred to can be gleaned, for example, from United States Patents US 5,296,891 and US 5,523,193, and PCT patent applications WO 98/38597 and WO 98/33096, which are incorporated herein by reference. In the case of a programmable mirror array, the said support structure may be embodied as a frame or table, for example, which may be fixed or movable as required; and

- A programmable LCD array. An example of such a construction is given in United States Patent US 5,229,872, which is incorporated herein by reference. As above, the support structure in this case may be embodied as a frame or table, for example, which may be fixed or movable as required.

For purposes of simplicity, the rest of this text may, at certain locations, specifically direct itself to examples involving a mask and mask table; however, the general principles discussed in such instances should be seen in the broader context of the patterning means as hereabove set forth.

Lithographic projection apparatus can be used, for example, in the manufacture of integrated circuits (ICs). In such a case, the patterning means may generate a circuit pattern corresponding to an individual layer of the IC, and this pattern can be imaged onto a target portion (e.g. comprising one or more dies) on a substrate (silicon wafer) that has been coated with a layer of radiation-sensitive material (resist). In general, a single wafer will contain a whole network of adjacent target portions that are successively irradiated via the projection system, one at a time. In current apparatus,

employing patterning by a mask on a mask table, a distinction can be made between two different types of machine. In one type of lithographic projection apparatus, each target portion is irradiated by exposing the entire mask pattern onto the target portion in one go; such an apparatus is commonly referred to as a wafer stepper or step-and-repeat apparatus. In an alternative apparatus — commonly referred to as a step-and-scan apparatus — each target portion is irradiated by progressively scanning the mask pattern under the projection beam in a given reference direction (the "scanning" direction) while synchronously scanning the substrate table parallel or anti-parallel to this direction; since, in general, the projection system will have a magnification factor M (generally < 1), the speed V at which the substrate table is scanned will be a factor M times that at which the mask table is scanned. More information with regard to lithographic devices as here described can be gleaned, for example, from US 6,046,792, incorporated herein by reference.

In a manufacturing process using a lithographic projection apparatus, a pattern (e.g. in a mask) is imaged onto a substrate that is at least partially covered by a layer of radiation-sensitive material (resist). Prior to this imaging step, the substrate may undergo various procedures, such as priming, resist coating and a soft bake. After exposure, the substrate may be subjected to other procedures, such as a post-exposure bake (PEB), development, a hard bake and measurement/inspection of the imaged features. This array of procedures is used as a basis to pattern an individual layer of a device, e.g. an IC. Such a patterned layer may then undergo various processes such as etching, ion-implantation (doping), metallization, oxidation, chemo-mechanical polishing, etc., all intended to finish off an individual layer. If several layers are required, then the whole procedure, or a variant thereof, will have to be repeated for each new layer. Eventually, an array of devices will be present on the substrate (wafer). These devices are then separated from one another by a technique such as dicing or sawing, whence the individual devices can be mounted on a carrier, connected to pins, etc. Further information regarding such processes can be obtained, for example, from the book "Microchip Fabrication: A Practical Guide to Semiconductor Processing", Third Edition, by Peter van Zant, McGraw Hill Publishing Co., 1997, ISBN 0-07-067250-4, incorporated herein by reference.

For the sake of simplicity, the projection system may hereinafter be referred to as the "lens"; however, this term should be broadly interpreted as encompassing various

types of projection system, including refractive optics, reflective optics, and catadioptric systems, for example. The radiation system may also include components operating according to any of these design types for directing, shaping or controlling the projection beam of radiation, and such components may also be referred to below, collectively or singularly, as a "lens". Further, the lithographic apparatus may be of a type having two or more substrate tables (and/or two or more mask tables). In such "multiple stage" devices the additional tables may be used in parallel, or preparatory steps may be carried out on one or more tables while one or more other tables are being used for exposures. Dual stage lithographic apparatus are described, for example, in US 5,969,441 and WO 98/40791, both incorporated herein by reference.

In a lithographic apparatus the size of features that can be imagined onto the substrate is limited by the wavelength of the projection radiation. To produce integrated circuits with a higher density of devices, and hence higher operating speeds, it is desirable to be able to image smaller features. Whilst most current lithographic projection apparatus employ ultraviolet light generated by mercury lamps or excimer lasers, it has been proposed to use shorter wavelength radiation in the range 5 to 20 nm, especially around 13 nm. Such radiation is termed extreme ultraviolet (EUV) or soft x-ray and possible sources include, for instance, laser-produced plasma sources, discharge plasma sources, or synchrotron radiation from electron storage rings. Apparatus using discharge plasma sources are described in: W. Partlo, I. Fomenkov, R. Oliver, D. Birx, "Development of an EUV (13.5 nm) Light Source Employing a Dense Plasma Focus in Lithium Vapor", Proc. SPIE 3997, pp. 136-156 (2000); M.W. McGeoch, "Power Scaling of a Z-pinch Extreme Ultraviolet Source", Proc. SPIE 3997, pp. 861-866 (2000); W.T. Silfvast, M. Klosner, G. Shimkaveg, H. Bender, G. Kubiak, N. Fornaciari, "High-Power Plasma Discharge Source at 13.5 and 11.4 nm for EUV lithography", Proc. SPIE 3676, pp. 272-275 (1999); and K. Bergmann et al., "Highly Repetitive, Extreme Ultraviolet Radiation Source Based on a Gas-Discharge Plasma", Applied Optics, Vol. 38, pp. 5413-5417 (1999).

EUV radiation sources may require the use of a rather high partial pressure of a gas or vapor to emit EUV radiation, such as discharge plasma radiation sources referred to above. In a discharge plasma source, for instance, a discharge is created in between electrodes, and a resulting partially ionized plasma may subsequently be caused to collapse to yield a very hot plasma that emits radiation in the EUV range. The very hot

plasma is quite often created in Xe, since a Xe plasma radiates in the Extreme UV (EUV) range around 13.5 nm. For an efficient EUV production, a typical pressure of 0.1 mbar is required near the electrodes to the radiation source. A drawback of having such a rather high Xe pressure is that Xe gas absorbs EUV radiation. For example, 0.1 mbar Xe transmits over 1 m only 0.3 % EUV radiation having a wavelength of 13.5 nm. It is therefore required to confine the rather high Xe pressure to a limited region around the source. To reach this the source can be contained in its own vacuum chamber that is separated by a chamber wall from a subsequent vacuum chamber in which the collector mirror and illumination optics may be obtained.

The vacuum wall can be made transparant to EUV radiation by a number of apertures in said wall provided by a channel array or so called foil trap such as described in European Patent application number EP-A-1 057 079 which is incorporated herein by reference. In order to reduce the number of particles propagating along the optical axis a channel array or "foil trap" has been proposed in EP-A-1 223 468 and EP-A-1 057 079. This foil trap consists of a channel like structure comprising walls as lamellas shaped close together in order to form a flow resistance but not too close as to let the radiation pass without obstructing it. This foil trap is incorporated herein by reference.

The contamination of the optical components of the lithography apparatus by relatively heavy, micron-sized particles or smaller particles provided that their velocity is relatively low, which are emitted by the EUV source and which pass the channel array in the vacuum wall of the source poses a serious problem, as this contamination results in degradation of the optical components and considerably increases the operational costs of an EUV lithographic projection apparatus.

It is therefore an object of the present invention to reduce or eliminate the number of particles that are emitted by the EUV source and that propagate along the optical axis.

It is another object to reduce the amount of contamination caused by the EUV source on optical components in an EUV lithographic projection apparatus.

This and other objects are achieved according to the present invention in a lithographic projection apparatus as specified in the opening paragraph, characterized in that the channel means is rotatable around the optical axis, the lithographic projection apparatus comprising drive means connected to the channel means for

rotating the channel means around the optical axis. By means of the rotating channel means particles emitted form the EUV source and travelling along the optical axis, are intercepted by the walls of the channel means which travel perpendicular to the optical axis and will stick there. In this way, the delicate optical components behind the channel means will be guarded against contamination.

In an embodiment of a lithographic projection apparatus according to the invention, the lithographic projection apparatus is characterized in that the channel members are focussed on the radiation source. Hereby EUV rays of radiation emitted from the EUV source may pass the channel means without obstruction. This is an important advantage because EUV radiation tends to be absorbed very easily.

The velocity of the heavy particles, such as debris comprising ablate, evaporated or sputtered electrode material emanating from the source is relatively low. From experiments, the speeds appear to be lower than 10 m/s. The aspect ratio of the channel members in the channel means (length/width ratio) is in the order of 20. When the channel means is rotated at a velocity of 10/20 = 0,5 m/s, virtually all the heavy particles emitted by the EUV source will hit the channel member walls and will be trapped in the walls.

In a further embodiment of the invention therefore the lithographic projection apparatus is characterized in that the drive means are adapted to rotate the channel means at a speed of between 1 and 50 rotations per second, preferably 1 and 10 rotations per second. These relatively low rotational velocities can be easily accomplished and no specialized, advanced and complex components are necessary.

Although specific reference may be made in this text to the use of the apparatus according to the invention in the manufacture of ICs, it should be explicitly understood that such an apparatus has many other possible applications. For example, it may be employed in the manufacture of integrated optical systems, guidance and detection patterns for magnetic domain memories, liquid-crystal display panels, thin-film magnetic heads, etc. The skilled artisan will appreciate that, in the context of such alternative applications, any use of the terms "reticle", "wafer" or "die" in this text should be considered as being replaced by the more general terms "mask", "substrate" and "target portion", respectively.

In the present document, the terms “radiation” and “beam” are used to encompass all types of electromagnetic radiation, including ultraviolet (UV) radiation (e.g. with a

wavelength of 365, 248, 193, 157 or 126 nm) and extreme ultra-violet (EUV) radiation (e.g. having a wavelength in the range 5-20 nm), as well as particle beams, such as ion beams or electron beams.

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying schematic drawings in which corresponding reference symbols indicate corresponding parts, and in which:

Fig. 1 schematically depicts a lithographic projection apparatus according to an embodiment of the invention;

Fig. 2. shows a side view of an EUV illuminating system and projection optics of a lithographic projection apparatus according to the invention;

Fig. 3 shows a detail of the radiation source and grazing incidence collector of the present invention;

Fig 4 shows in a cross-section a schematic drawing of the rotating particle barrier means according to the present invention.

Fig. 1 schematically depicts a lithographic projection apparatus 1 according to a particular embodiment of the invention. The apparatus comprises:

- a radiation system Ex, IL, for supplying a projection beam PB of radiation (e.g. EUV radiation) with a wavelength of 11-14 nm. In this particular case, the radiation system also comprises a radiation source LA;
- a first object table (mask table) MT provided with a mask holder for holding a mask MA (e.g. a reticle), and connected to first positioning means PM for accurately positioning the mask with respect to item PL;
- a second object table (substrate table) WT provided with a substrate holder for holding a substrate W (e.g. a resist-coated silicon wafer), and connected to second positioning means PW for accurately positioning the substrate with respect to item PL; and
- a projection system ("lens") PL for imaging an irradiated portion of the mask MA onto a target portion C (e.g. comprising one or more dies) of the substrate W.

As here depicted, the apparatus is of a transmissive type (i.e. has a transmissive mask). However, in general, it may also be of a reflective type, for example (with a reflective mask). Alternatively, the apparatus may employ another kind of patterning means, such as a programmable mirror array of a type as referred to above.

The source LA (e.g. a laser-produced plasma or a discharge plasma EUV radiation source) produces a beam of radiation. This beam is fed into an illumination system (illuminator) IL, either directly or after having traversed conditioning means, such as a beam expander Ex, for example. The illuminator IL may comprise adjusting means AM for setting the outer and/or inner radial extent (commonly referred to as σ-outer and σ-inner, respectively) of the intensity distribution in the beam. In addition, it will generally comprise various other components, such as an integrator IN and a condenser CO. In this way, the beam PB impinging on the mask MA has a desired uniformity and intensity distribution in its cross-section.

It should be noted with regard to Fig. 1 that the source LA may be within the housing of the lithographic projection apparatus (as is often the case when the source LA is a mercury lamp, for example), but that it may also be remote from the lithographic projection apparatus, the radiation beam which it produces being led into the apparatus (e.g. with the aid of suitable directing mirrors); this latter scenario is often the case when the source LA is an excimer laser. The current invention and claims encompass both of these scenarios.

The beam PB subsequently intercepts the mask MA, which is held on a mask table MT. Having traversed the mask MA, the beam PB passes through the lens PL, which focuses the beam PB onto a target portion C of the substrate W. With the aid of the second positioning means PW (and interferometric measuring means IF), the substrate table WT can be moved accurately, e.g. so as to position different target portions C in the path of the beam PB. Similarly, the first positioning means PM can be used to accurately position the mask MA with respect to the path of the beam PB, e.g. after mechanical retrieval of the mask MA from a mask library, or during a scan. In general, movement of the object tables MT, WT will be realized with the aid of a long-stroke module (coarse positioning) and a short-stroke module (fine positioning), which are not explicitly depicted in figure 1. However, in the case of a wafer stepper (as opposed to a step-and-scan apparatus) the mask table MT may just be connected to a short stroke actuator, or may be fixed. Mask MA and substrate W may be aligned using mask alignment marks M1, M2 and substrate alignment marks P1, P2.

The depicted apparatus can be used in two different modes:

1. In step mode, the mask table MT is kept essentially stationary, and an entire mask image is projected in one go (i.e. a single "flash") onto a target portion C. The substrate

table WT is then shifted in the x and/or y directions so that a different target portion C can be irradiated by the beam PB; and

2. In scan mode, essentially the same scenario applies, except that a given target portion C is not exposed in a single "flash". Instead, the mask table MT is movable in a given direction (the so-called "scan direction", e.g. the y direction) with a speed v, so that the projection beam PB is caused to scan over a mask image; concurrently, the substrate table WT is simultaneously moved in the same or opposite direction at a speed $V = Mv$, in which M is the magnification of the lens PL (typically, $M = 1/4$ or $1/5$). In this manner, a relatively large target portion C can be exposed, without having to compromise on resolution.

Fig. 2 shows the projection apparatus 1 comprising an illumination system IL with radiation unit 3, illumination optics unit 4, and projection optics system PL. The radiation system 2 comprises a source-collector module or radiation unit 3 and an illumination optics unit 4. Radiation unit 3 is provided with a radiation source LA which may be formed by a discharge plasma. EUV radiation source 6 may employ a gas or vapor, such as Xe gas or Li vapor in which a very hot plasma may be created to emit radiation in the EUV range of the electromagnetic spectrum. The very hot plasma is created by causing a partially ionized plasma of an electrical discharge to collapse onto the optical axis O. Partial pressures of 0.1 mbar of Xe, Li vapor or any other suitable gas or vapor may be required for efficient generation of the radiation. The radiation emitted by radiation source LA is passed from the source chamber 7 into collector chamber 8 via a gas barrier structure or "foil trap" 9. The gas barrier structure comprises a channel structure such as, for instance, described in detail in European patent applications EP-A-1 233 468 and EP-A-1 057 079, which is incorporated herein by reference.

The collector chamber 8 comprises a radiation collector 10 which according to the present invention is formed by a grazing incidence collector. Radiation passed by collector 10 is reflected off a grating spectral filter 11 or mirror to be focused in a virtual source point 12 at an aperture in the collector chamber 8. From chamber 8, the projection beam 16 is reflected in illumination optics unit 4 via normal incidence reflectors 13, 14 onto a reticle or mask positioned on reticle or mask table MT. A patterned beam 17 is formed which is imaged in projection optics system PL via

reflective elements 18, 19 onto wafer stage or substrate table WT. More elements than shown may generally be present in illumination optics unit 4 and projection system PL.

As can be seen in Fig. 3, the grazing incidence collector 10 comprises a number of nested reflector elements 21, 22, 23. A grazing incidence collector of this type is, for instance, shown in German patent application DE 101 38 284.7.

The embodiment of the rotating channel array or barrier 43 invention as shown in figure 4 shows the EUV source 6 from which EUV radiation 6' emanates. The beams 6' impinge on the barrier 43 forming part of a vacuum wall separating the source chamber from the UV optics downstream of the optical axis. The barrier 43 is rotatable around the optical axis O, as indicated by the arrow. It is also possible for the barrier 43 to rotate around the optical axis 47 in a direction opposite to the direction of the arrow or alternately rotate in one direction or the other. The center 44 of the barrier 43 and is located on the optical axis. The barrier 43 may be cylindrically symmetric along an optical axis 47. The barrier may also be invariant when rotated over some specific angles only. The barrier 43 comprises a lamellar structure 41. The mutual distance between the different lamellas can vary as shown for a segment 42 of the barrier 43. This means that the distance between consecutive lamellas may vary. The lamellar structure 41 forms viewed in 3D, small channels. The channels may be focussed on the radiation source 6. It is also possible to construct a channel array 43 without a real focus. The channels are, however, parallel with the emitted EUV beam. The principal idea behind the invention is that contaminating particles 45 in the EUV radiation 6' will, due to rotation of the barrier 43 stick to the inside of the lamellar structure 41 through which the EUV radiation 6' propagates. The barrier 43 is rotatable for instance by drive means 46 located on both sides of the barrier 43, which rotational speeds of about 7 rotations per second. The lamellar structure 41 is focussed on the radiation source. Hereby EUV rays of radiation emitted from the EUV source may pass the lamellar structure 41 without obstruction. Typical values for the dimensions of the lamellar structure 41 are: platelats: height 30 mm, thickness 0.1 mm and width 50 mm (curved). A typical value for the channel width is 1 mm. The distance from the barrier 43 to the source 6 is typically in the order of 60 mm.

When the rotation of the foil trap is not synchronized with the pulse frequency of the source, stroboscopic effects can occur. To circumvent stroboscopic effects, the foil

trap should be rotated exactly an integer number of channels in between two pulses of the source.

While specific embodiments of the invention have been described above, it will be appreciated that the invention may be practiced otherwise then as described. The description is not intended to limit the invention.

CLAIMS

1. A lithographic projection apparatus (1) comprising:

- a radiation system (3, 4) to form a projection beam (6) of radiation, from radiation emitted by a radiation source (6),
- a support structure (15) constructed to hold patterning means, to be irradiated by the projection beam to pattern said projection beam,
- a substrate table (20) constructed to hold a substrate, and
- a projection system (5) constructed and arranged to image an irradiated portion of the patterning means onto a target portion of the substrate,

and a channel means (9, 43) near the source for preventing material emanating from the source (6) from propagating along an optical axis (47), the channel means (43) comprising a center (44) and a number of elongated wall members (41) having a width direction transverse to the optical axis (47) and a length direction extending generally in the direction of the optical axis (47),

characterized in that

the channel means (43) is rotatable around the optical axis (47), the lithographic projection apparatus (1) comprising drive means (46) connected to the channel means (43) for rotating the channel means (43) around the optical axis (47).

2. A lithographic projection apparatus (1) according to claim 1 characterized in that the center (44) of the channel means (43) is placed on the optical axis (47).

3. A lithographic projection apparatus (1) according to claim 1 or 2 characterized in that the channel members (41) are focussed on the radiation source (6).

4. A lithographic projection apparatus according to claim 1, 2 or 3 characterized in that the wall members (41) of the channel means (43) are plate-shaped.

5. A lithographic projection apparatus (1) according to any of the preceding claims characterized in that the channel members (41) located close to the optical axis (47)

form a honeycomb structure in a plane perpendicular to the optical axis (47) and extend parallel or substantially parallel to the optical axis (47).

6. A lithographic projection apparatus (1) according to any of the preceding claims, the drive means (46) being adapted to rotate the channel means (43) at a speed of between 1 and 50 rotations per second, preferably 1 and 10 rotations per second.

7. Channel means assembly for use in a lithographic projection apparatus (1) according to any of the preceding claims, comprising a number of elongated wall members (41) having a width direction transverse to an optical axis (47) and a length direction extending generally in the direction of the optical axis (47), characterized in that the channel means (43) are rotatable around an optical axis (47), the channel means assembly comprising drive means (46) connected to the channel means for rotating the channel means (43) around the optical axis (47).

8. Method of manufacturing an integrated structure by a lithographic process comprising the steps of:

- providing a radiation system (3, 4) to form a projection beam (6) of radiation, from radiation emitted by a radiation source (6),
- providing a support structure (15) constructed to hold patterning means, to be irradiated by the projection beam to pattern said projection beam,
- providing a substrate table (20) constructed to hold a substrate, and
- providing a projection system (5) constructed and arranged to image an irradiated portion of the patterning means onto a target portion of the substrate,

and a channel means (9, 43) near the source for preventing material emanating from the source (6) from propagating along an optical axis (47), the channel means (43) comprising a center (44) and a number of elongated wall members (41) having a width direction transverse to the optical axis (47) and a length direction extending generally in the direction of the optical axis (47),

characterized in that

the channel means (43) is rotatable around the optical axis (47), the lithographic projection apparatus (1) comprising drive means (46) connected to the channel means (43) for rotating the channel means (43) around the optical axis (47).

Abstract

The invention is a lithographic projection apparatus for EUV lithography which has a foil trap. This foil trap forms an open structure after the EUV source to let the EUV radiation pass unhindered. The foil trap is constructed to be rotatable around the optical axis. By rotating the foil trap an impulse transverse to the direction of propagation of the EUV radiation can be transferred on debris present in the EUV beam. This debris will not pass the foil trap. In this way, the amount of debris on the optical components downstream of the foil trap is reduced.

Fig. 4

Fig 1

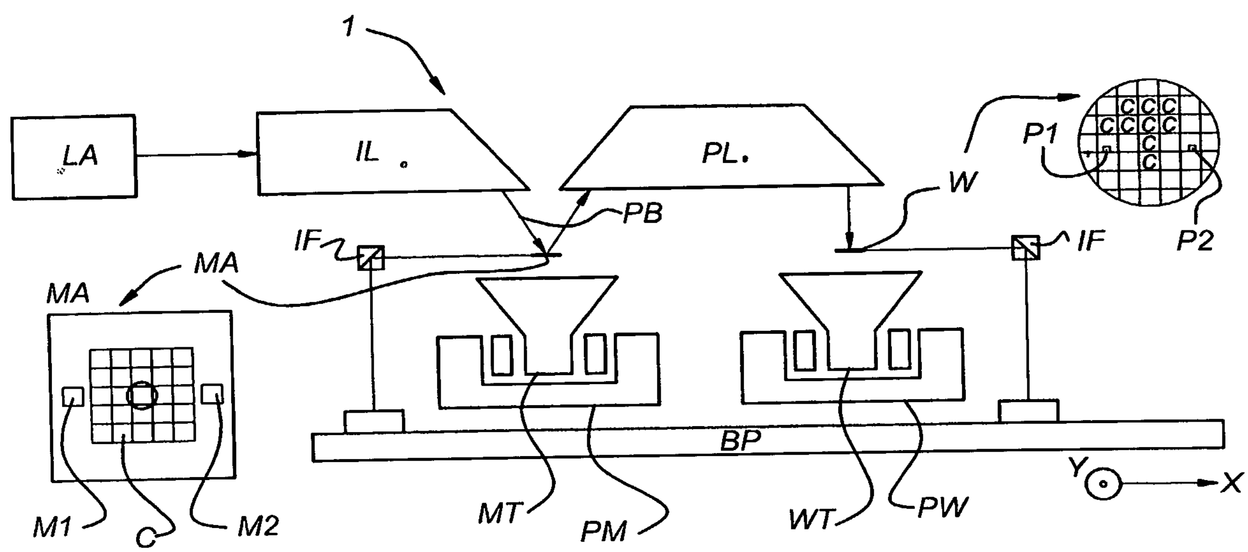
1
LA
IL
PL
PB
W
P1
P2
C
IF
IF
MA
MA
BP
M1
C
M2
MT
PM
WT
PW
Y
X

Fig 2

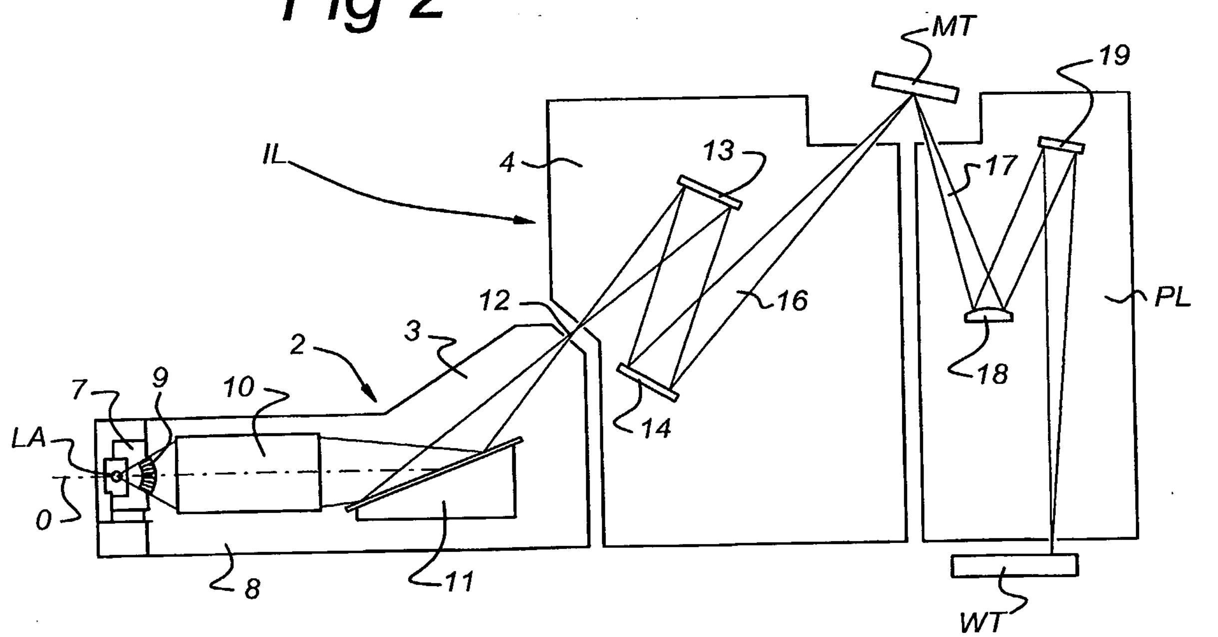
MT
19
IL
4
13
17
12
16
PL
2
3
18
7
9
10
14
LA
0
8
11
WT

Fig 3

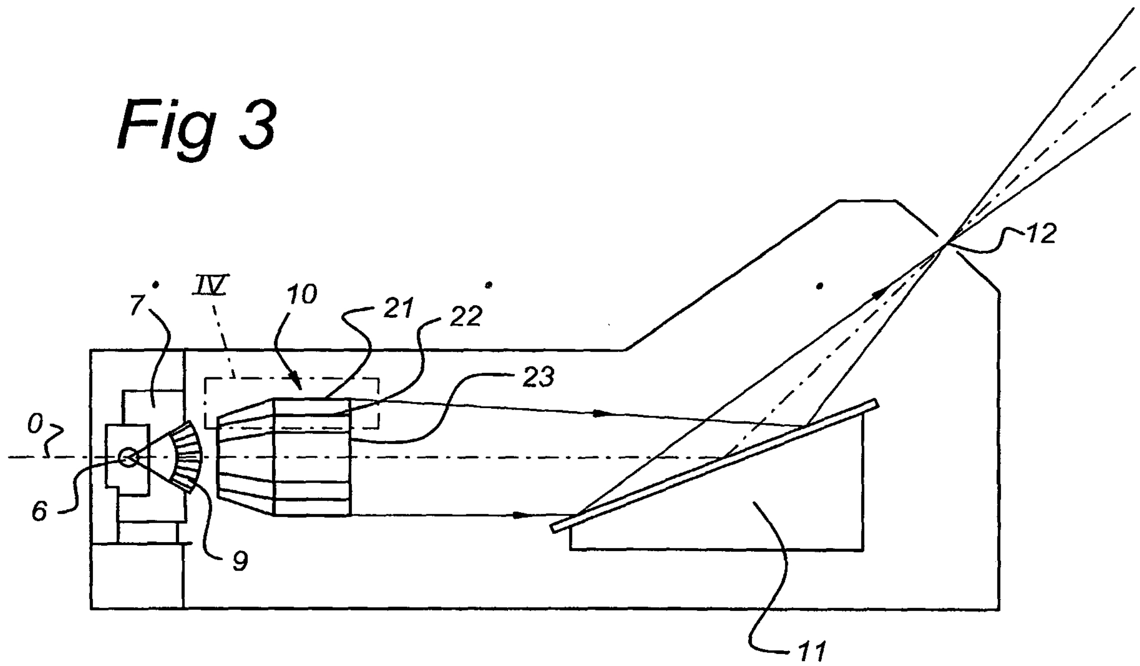

Fig 4